Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

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General Certificate of Education
June 2003
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

ELECTRONICS ELE2
Unit 2 Further Electronics

Wednesday 21 May 2003 Morning Session

In addition to this paper you will require:
- a calculator;
- a pencil and a ruler.

Time allowed: 1 hour 30 minutes

Instructions
- Use blue or black ink or a ball-point pen. Use a pencil for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. All working must be shown.
- Do all rough work in this book. Cross through any work you do not want marked.
- A *Data Sheet* is provided on pages 3 and 4. Detach this perforated sheet at the start of the examination.

Information
- The maximum mark for this paper is 72.
- Mark allocations are shown in brackets.
- Any correct electronics solution will gain credit.
- The paper carries 40% of the total marks for Electronics Advanced Subsidiary and 20% of the total marks for Electronics Advanced level awards.
- You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
3			
4			
5			
6			
7			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Data Sheet

Resistors

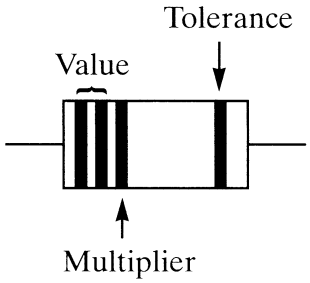
Preferred values for resistors (E24) series:
1.0, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1 ohms and multiples that are ten times greater.

Resistor Printed Code (BS 1852)

This code consists of letters and numbers:
R means $\times 1$
K means $\times 1000$ (i.e. 10^3)
M means $\times 1\,000\,000$ (i.e. 10^6)
Position of the letter gives the decimal point
Tolerances are given by the letter at the end of the code, F = ± 1%, G = ± 2%, J = ± 5%, K = ± 10%, M = ± 20%.

Resistor Colour Code

Number	Colour
0	Black
1	Brown
2	Red
3	Orange
4	Yellow
5	Green
6	Blue
7	Violet
8	Grey
9	White



Tolerance, gold = ± 5%, silver = ± 10%, no band ± 20%.

Silicon diode

$V_F = 0.7\,V$

Silicon transistor

$V_{be} \approx 0.7\,V$ in the on state
$V_{ce} \approx 0.2\,V$ when saturated

Resistance

$R_T = R_1 + R_2 + R_3$ series

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ parallel

Capacitance

$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ series

$C_T = C_1 + C_2 + C_3$ parallel

Time constant

$T = CR$

ac theory

$I_{rms} = \frac{I_o}{\sqrt{2}}$

$V_{rms} = \frac{V_o}{\sqrt{2}}$

$X_C = \frac{1}{2\pi fC}$ reactance

$X_L = 2\pi fL$ reactance

$f = \frac{1}{T}$ frequency, period

$f_o = \frac{1}{2\pi\sqrt{LC}}$ resonant frequency

Turn over ▶

Operational amplifier

$G_V = \frac{V_{out}}{V_{in}}$ voltage gain

$G_V = -\frac{R_f}{R_1}$ inverting

$G_V = 1 + \frac{R_f}{R_1}$ non-inverting

$V_{out} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$ summing

Astable and Monostable using NAND Gates

$f \approx \frac{1}{2RC}$ astable

$T \approx RC$ monostable

555 Astable and Monostable

$T = 1.1RC$ monostable

$t_H = 0.7(R_A + R_B)C$
$t_L = 0.7R_BC$] astable

$f = \frac{1.44}{(R_A + 2R_B)C}$ two resistor circuit

Electromagnetic Waves

$c = 3 \times 10^8\ m\,s^{-1}$ speed in vacuo

List of BASIC Commands

DIM variable [(subscripts)]

DO [{**WHILE** | **UNTIL**} condition]
    [statement block]
LOOP

DO
    [statement block]
LOOP [{**WHILE** | **UNTIL**} condition]

FOR counter = start **TO** end [**STEP** increment]
    [statement block]
NEXT counter

GOSUB [label | line number]
    [statement block]
RETURN

IF condition **THEN**
    [statement block 1]
ELSE
    [statement block 2]

INKEY$

INP (port %)

INPUT [;] ["prompt" {;1, }] variable list (comma separated)

LPRINT [expression list] [{ ;1, }]

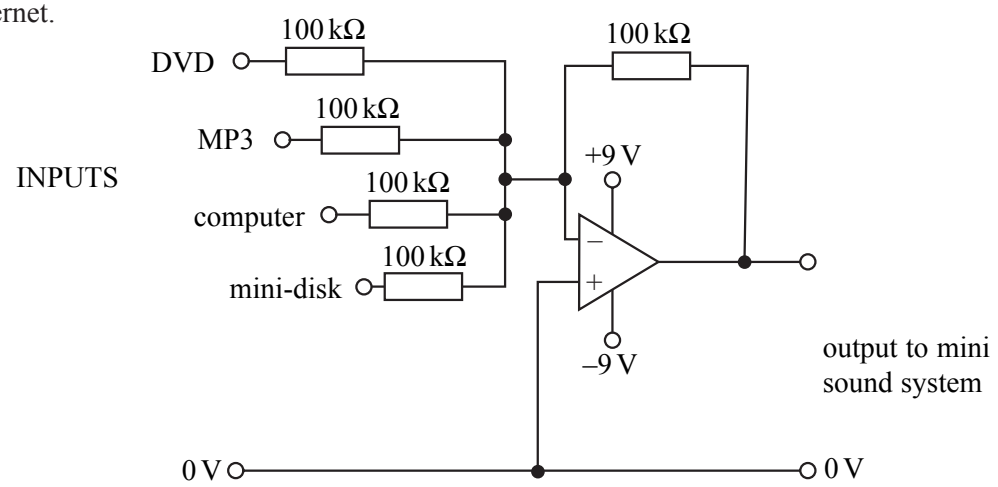
OUT port%, data%

PRINT [expression list] [{;1,}]

REM remark

Answer **all** questions in the spaces provided.

1 A student has a mini sound system with an internal CD player, which has one auxiliary input socket to connect to other sound devices e.g. a mini-disk player. However, this one socket is inadequate since, along with a mini-disk player, she also wants to be able to connect her computer, a portable MP3 player and a DVD player. To overcome this problem she builds the circuit shown below, which she found on the Internet.



(a) What is the name of this type of circuit? .....

(1 mark)

(b) In operation, she found that the sound from any of the four additional players was quieter than from the internal CD player. Using an oscilloscope, she measured the peak output from the internal CD player as 1 V but from the circuit above as only 200 mV. Explain what change you would make to the feedback resistor to ensure that the sound levels were the same from all of the players.

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(3 marks)

(c) With this problem solved, she decides that she needs yet another input to which she could connect an electric guitar. The peak output from the guitar is 50 mV.

(i) Mark onto the diagram above where this additional input should be connected along with the additional component that is needed.

(ii) Calculate a suitable value for the additional component that is needed.

.....

.....

.....

(5 marks)

2 The sequence of operations for a dishwasher is shown below. Each step is given a binary code corresponding to the output from a 4-bit down counter.

Operation	**D**	**C**	**B**	**A**
START	0	0	0	0
Pump on to empty any fluids from the dishwasher	1	1	1	1
Cold water valve on until there is sufficient water present	1	1	1	0
Pump on for the spray unit for 300 s to wash dishes	1	1	0	1
Pump on to empty the dishwasher of water	1	1	0	0
Cold water valve on until there is sufficient water present	1	0	1	1
Heater on to heat water to 65 °C	1	0	1	0
Release dishwasher powder into water	1	0	0	1
Pump on for the spray unit for 900 s to wash dishes	1	0	0	0
Pump on to empty the dishwasher of water	0	1	1	1
Cold water valve on until there is sufficient water present	0	1	1	0
Heater on to heat water to 65 °C	0	1	0	1
Release rinse aid into water	0	1	0	0
Pump on for the spray unit for 300 s to rinse dishes	0	0	1	1
Pump on to empty the dishwasher of water	0	0	1	0
Heater on until the dishes are dry	0	0	0	1
STOP	0	0	0	0

(a) State both the decimal and hexadecimal equivalents of the binary code corresponding to the operation:

"Pump on to empty any fluids from the dishwasher".

.....

.....

(2 marks)

(b) Explain why the Boolean expression for when the heater is on is

$$\mathbf{Q = D\bar{C}B\bar{A} + \bar{D}C\bar{B}A + \bar{D}\bar{C}\bar{B}A}$$

.....

.....

.....

(3 marks)

(c) Show, using **either** Boolean Algebra or a Karnaugh map, that the Boolean expression simplifies to

$$\mathbf{Q = \bar{D}\bar{B}A + D\bar{C}B\bar{A}}$$

D.C \ B.A	00	01	11	10
00				
01				
11				
10				

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(2 marks)

7

3 As part of a sonar system for use on a submarine, a hydrophone (microphone which operates under water) has to be interfaced to a computer. An extract from the data sheet for the hydrophone is shown in **Figure 1**.

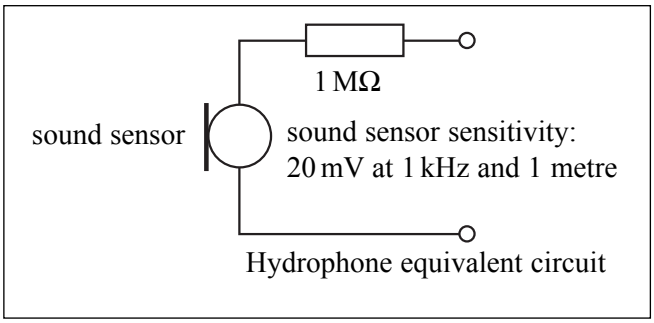

Figure 1

The computer requires the sound sensor to have a sensitivity of 2 V at 1 kHz and 1 metre.

(a) Show that the voltage gain of the amplifier required to amplify the signal from the hydrophone for the computer is 100.

.....

(1 mark)

(b) The amplifier circuit shown in **Figure 2** is designed to amplify the signal from the hydrophone.

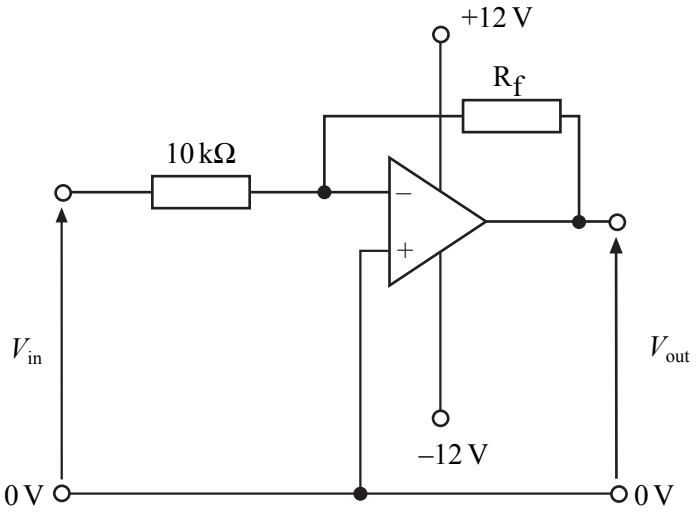

Figure 2

(i) Label the virtual earth point on the amplifier with a P.

(ii) Calculate a suitable value for the feedback resistor R_f to give the required gain.

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.....

(iii) What is the input resistance of the circuit?

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(4 marks)

(c) The amplifier was constructed correctly and when tested was found to have a voltage gain of 100. It was then connected to the hydrophone. Under the test conditions of the data sheet, the output from the amplifier was approximately 20 mV and not the 2 V expected. Explain why the output is not the expected value.

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(2 marks)

(d) A trainee electronics engineer working on the project was unable to solve the mystery and so rebuilt the amplifier as a non inverting amplifier with a voltage gain of approximately 100. Complete the circuit diagram in **Figure 3** for a non-inverting amplifier and mark onto it suitable values for the resistors and label the input.

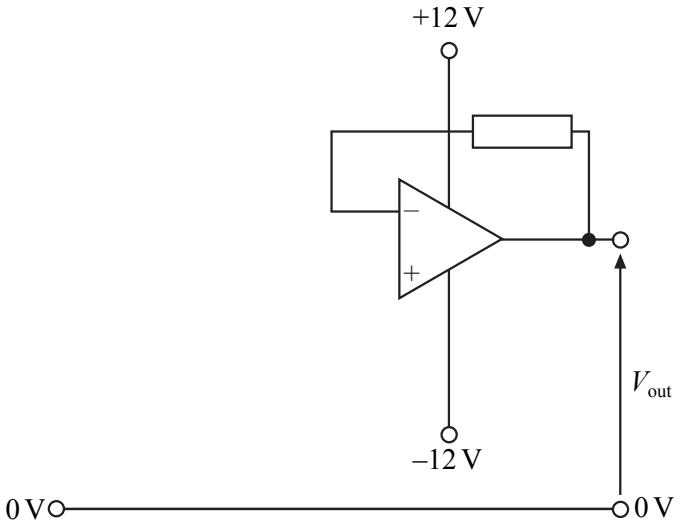

Figure 3

(3 marks)

(e) When connected to the hydrophone the arrangement gave the predicted output. What property of the non-inverting amplifier made the arrangement function correctly in this application?

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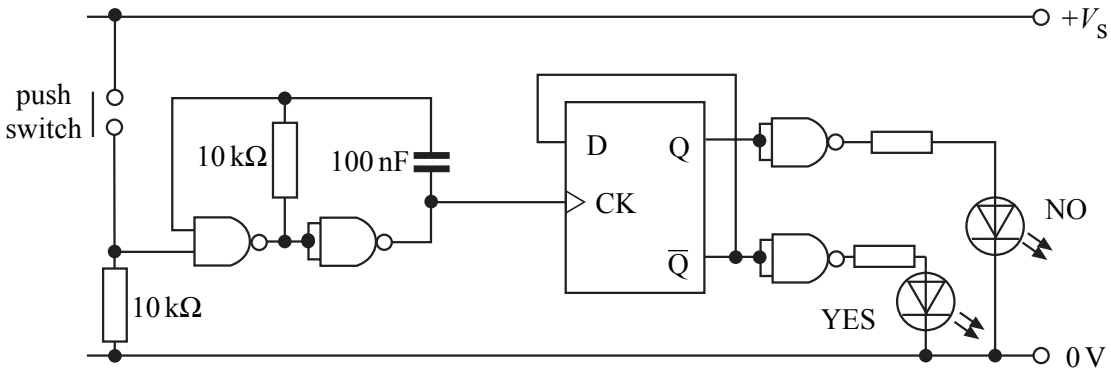
(1 mark)

11

4 To help his father, who has difficulty making decisions, a student builds a "Decision Maker". The circuit diagram is shown below. When a decision has to be made, the switch is pressed for a short time and then released. Whichever LED remains illuminated gives the decision (YES or NO).



(a) Explain how the NAND gate astable functions when the switch is pressed.

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(5 marks)

(b) Show that the frequency of the astable is approximately 500 Hz while the switch is pressed.

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(2 marks)

(c) During the time the switch is being pressed,

(i) describe the action of the D-type flip-flop.

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.....

(ii) describe the behaviour of the LEDs.

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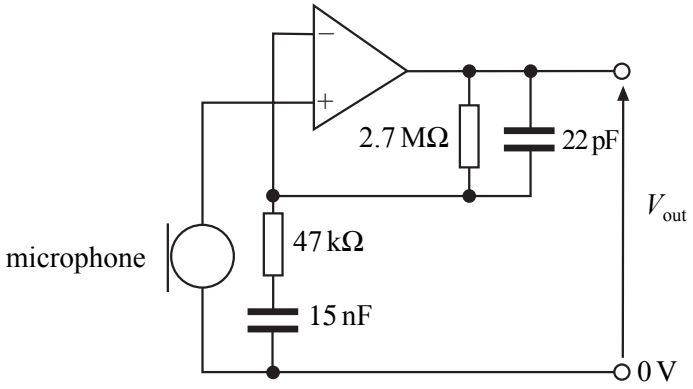
(3 marks)

10

5 The public address system at a railway station only requires frequencies in the range 200 Hz to 3000 Hz and needs all other frequencies to be attenuated. The circuit below is designed to interface the microphone to the amplifier to produce this requirement.



(a) Calculate the reactance of the 15 nF capacitor at a frequency of 200 Hz.

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(2 marks)

(b) The reactance of the 22 pF capacitor is 3.6 MΩ at 2 kHz.
Estimate the voltage gain of this circuit at a frequency of 2 kHz, showing how you arrived at your answer.

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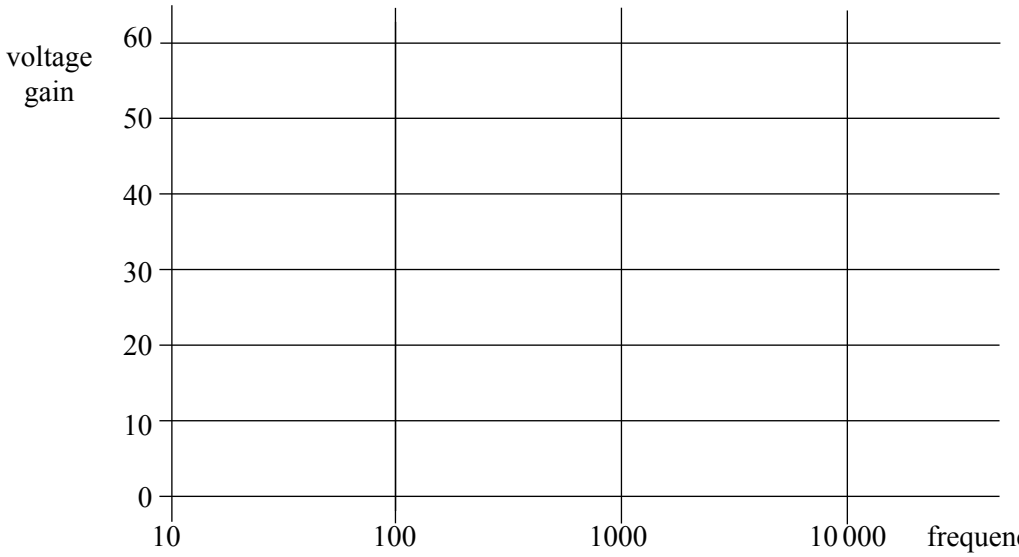
(3 marks)

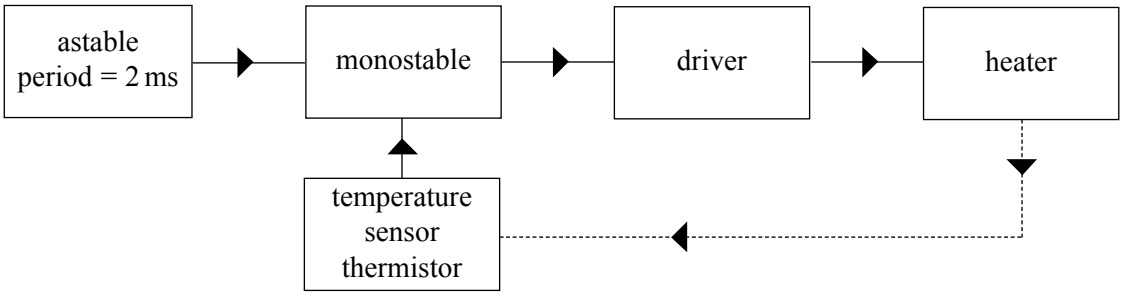
(c) On the axes below sketch how the voltage gain of the circuit varies with frequency.



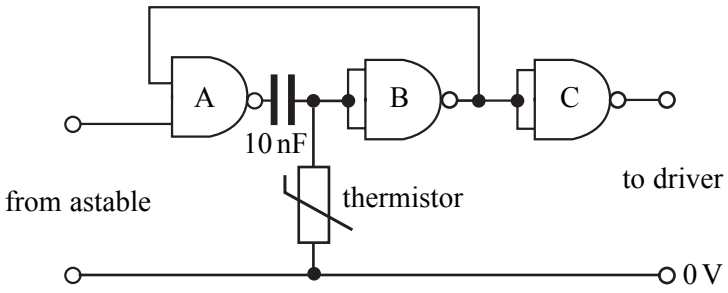
(3 marks)

8

6 The block diagram for a constant temperature control system of a greenhouse heater is shown below.



The circuit diagram for the monostable is shown below.



(a) When does the astable output trigger the monostable?

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(1 mark)

(b) Explain how the monostable functions.

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(4 marks)

(c) When the thermistor is cold it has a resistance of 180 kΩ and when it is hot it has a resistance of 10 kΩ.

(i) Show that the time period of the monostable when the thermistor is cold is 1.8 ms.

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.....

(ii) Calculate the time period of the monostable when the thermistor is hot.

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(2 marks)

(d) Explain how the system is able to provide a constant temperature.

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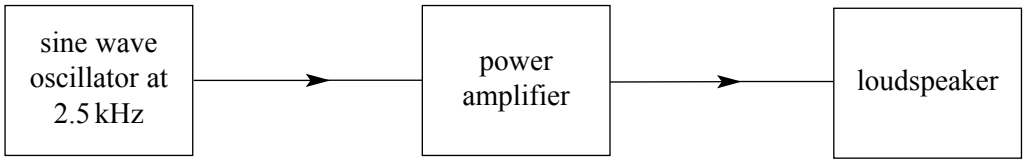
(2 marks)

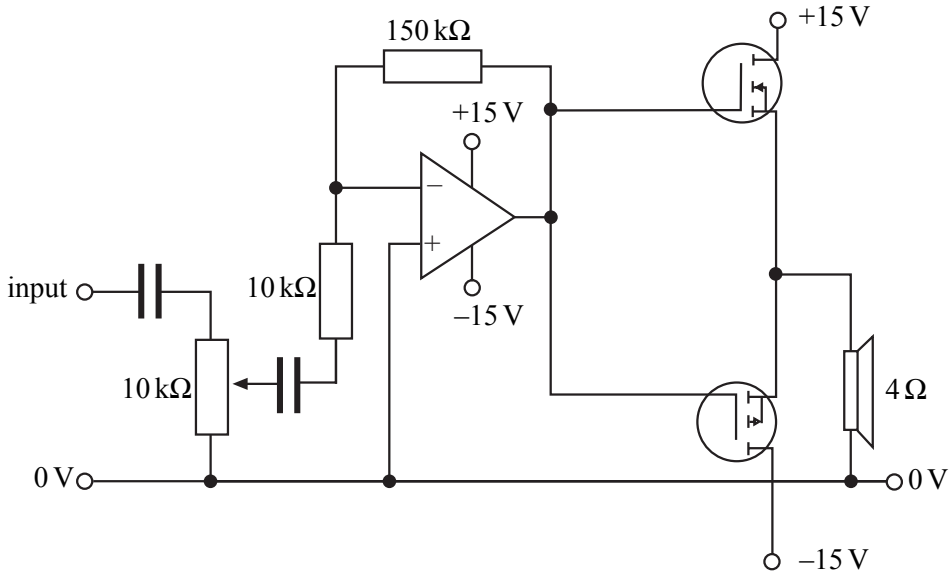
9

TURN OVER FOR THE NEXT QUESTION

7 The system diagram for a very loud alarm is shown below.



The circuit diagram of the power amplifier is shown below.



(a) What is the purpose of the potentiometer?

.....

(1 mark)

(b) (i) Estimate the maximum voltage that can be produced across the loudspeaker, stating an assumption that you make.

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.....

(ii) Estimate the voltage gain of the power amplifier, stating an assumption that you make.

.....

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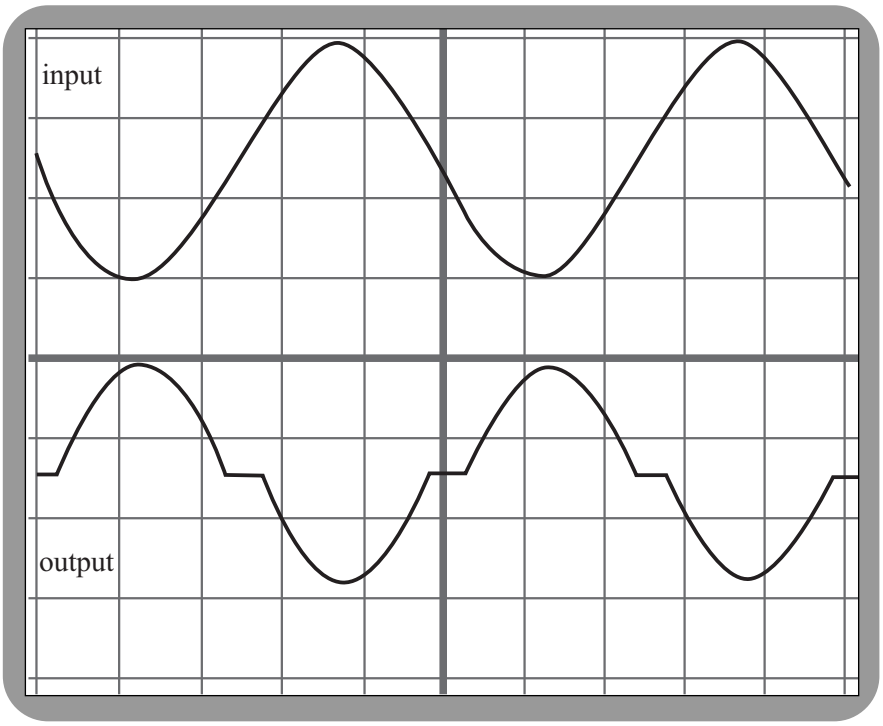
(4 marks)

(c) An oscilloscope connected to the input and output signals shows the traces below.



(i) State the name of the distortion that can be seen in the output waveform.

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(ii) State and explain **two** ways in which the distortion can be reduced.

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(iii) Explain why the distortion does not matter in this application.

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(6 marks)

QUESTION 7 CONTINUES ON THE NEXT PAGE

(d) (i) At full volume the rms current passing through the loudspeaker was measured as 2.3A. Show that the mean power output of the alarm is approximately 21W.

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(ii) The mean power supplied to the power amp from the power supply at full volume is 35 W. Explain why it is essential that the MOSFETs are bolted to heat sinks in this application.

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(4 marks)

(e) Describe **three** important properties of heat sinks.

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(3 marks)

18

END OF QUESTIONS